Center for Satellite and Hybrid Communication Networks

CSHCN

Overview

John S. Baras

Industry Advisory Board Meeting
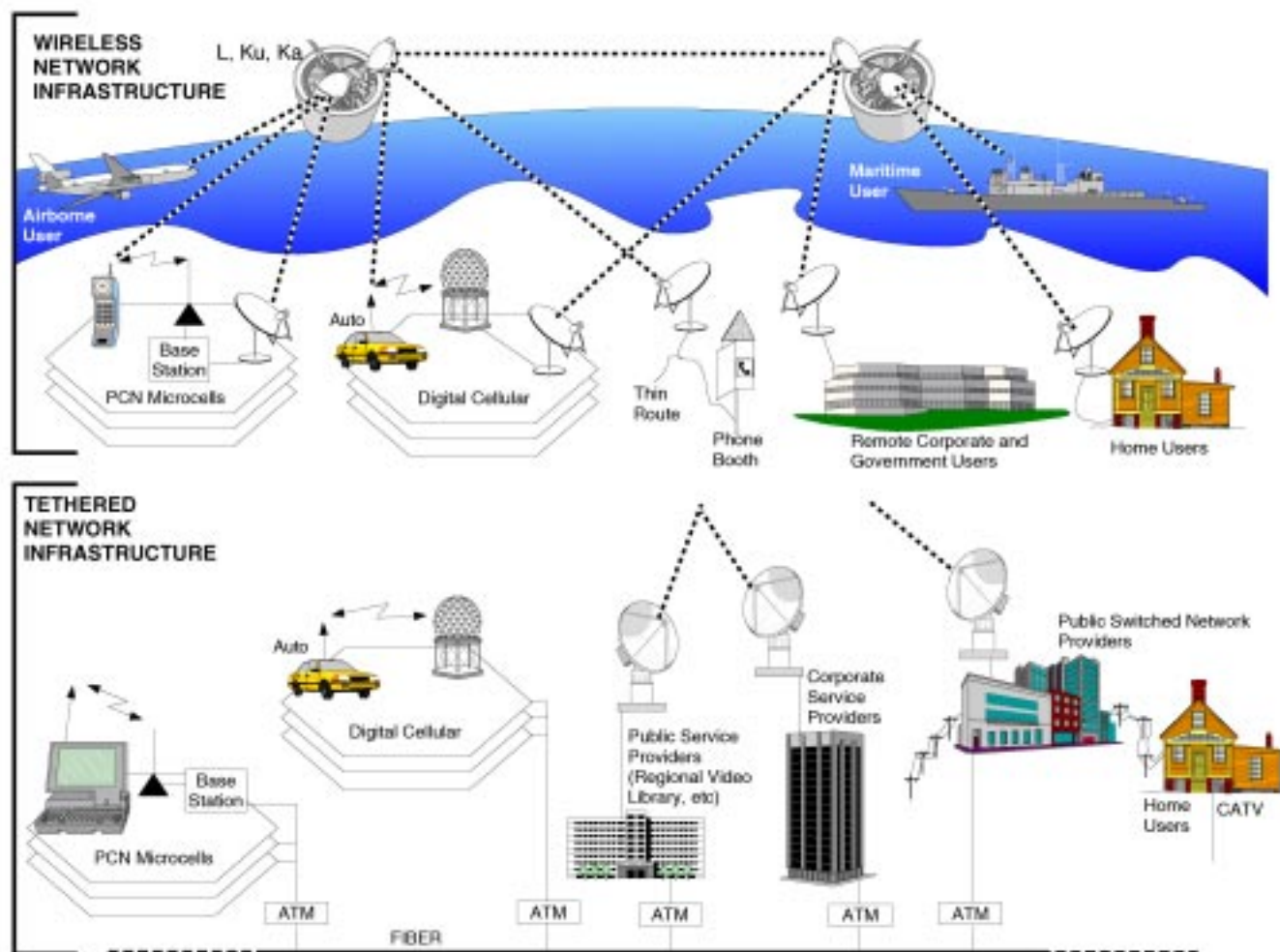February 17, 1999

Outline

- <u>CSHCN Structure and Partners</u>

- Highlights of Major Accomplishments

- Technical Theme and Vision

- Collaboration with NASA and Support of NASA Missions

- Collaboration with Industry

- Education and Outreach

- Financial Summary

Hybrid Networks

Center for Satellite & Hybrid Communication Networks

CSHCN

University of Maryland, College Park
College of Engineering
- Institute for Systems Research
- Engineering Research Center
- Electrical Engineering Department
- Computer Science Department
- College of Business and Management

University of Colorado, Boulder
College of Engineering and Applied Science
- Optoelectronics Center (NSF)
- Telecommunications Lab
- ECE Lab

Johns Hopkins University
Applied Physics Lab (APL)
Whiting School of Engineering

- Electrical Engineering Department

Industry Partners

- AT&T
- Bell Atlantic
- Bellcore
- Boeing
- COMSAT Laboratories
- FORE Systems
- GTE

- Hughes Network Systems
- Hughes Space & Communications
- IBM
- Lockheed Martin Corporation
- Lockheed Martin Telecommunications
- Motorola
- Orbital Sciences Corporation

- Philips
- Sanders, A Lockheed Martin Corporation
- Space Systems Loral
- Superconducting Core Technologies, Inc.
- Tektron
- Telesystems
- TRW
- U.S. Sprint

4

Center for Satellite & Hybrid Communication Networks

CSHCN

Industry Advisory Board (1998)

Mr. Jim Bagwell
Manager, Commercial Space Communications
NASA Lewis Research Center

Dr. Thomas A. Brackey
Director, Technical Operations
Hughes Space & Communications

Dr. Prakash Chitre
Vice President, Technology Development
COMSAT Laboratories

Dr. Leonard Golding
Vice President, Systems Engineering
Hughes Network Systems

Mr. Burt Liebowitz
Chief Technical Officer
Loral Orion

Dr. Ron Paulson
Vice President, Engineering and Technology
Lockheed Martin Space & Strategic Missiles

Dr. Robert Bonometti
President
Strategic Technology Decision

Dr. Joseph Bravman
Senior Vice President
Orbital Sciences Corporation

Dr. Luis Figueroa
Manager, Strategy & Analysis
The Boeing Company

Dr. Milton Halem
Chief, Space Data and Computing Division
NASA Goddard Space Flight Center

Mr. Roger Mancuso
Vice President, Technical Operations
Lockheed Martin Telecommunications

Mr. Rocky Roccanova
Vice President
TRW Telecom Group

5

CSHCN Faculty and Research Staff

Faculty

- Dr. Michael Ball (BMGT/ISR)
- Dr. John Baras (EE/ISR)
- Dr. Frank Barnes (University of Colorado)
- Dr. Scott Corson (ISR)
- Dr. Anthony Ephremides (EE/ISR)
- Dr. Evaggelos Geraniotis (EE/ISR)
- Dr. Nariman Farvardin (EE/ISR)
- Dr. Armand Makowski (EE/ISR)
- Dr. Prakash Narayan (EE/ISR)
- Dr. Catherine Plaisant (UMIACS)
- Dr. Nicholas Roussopoulos (CS/UMIACS)
- Dr. Ben Shneiderman (CS/ISR)
- Dr. Leandros Tassiulas (EE/ISR)
- Dr. Roger Westgate (John Hopkins University)

Research Staff

- Dr. Michael Hadjitheosodiou (ISR)
- Dr. George Mykoniatis (ISR)
- Mr. Steve Kelly (UMIACS)
- Mr. Spyro Papademetriou (ISR)

History at a Glance

- Initiated emphasis on hybrid networks

- Commercial successes in Hybrid Internet, Multiple access and modulation schemes, Multicasting, Network Management

- Research funding from NASA, DoD and industry has created a unique expertise

- More recent activity: bring this expertise to support high priority NASA missions:
  - Broadband communication to the ISS
  - Efficient distribution of NASA and space data
  - Support the move of NASA networks, spacecraft and instruments on the Internet

Outline

- CSHCN Structure and Partners

- <u>Highlights of Major Accomplishments</u>

- Technical Theme and Vision

- Collaboration with NASA and Support of NASA Missions

- Collaboration with Industry

- Education and Outreach

- Financial Summary

Highlights of Major Accomplishments

- **CONGRATULATIONS TO ALL FOR THE EXCELLENT PEER REVIEW REPORT!**

- **Presence/participation in national forums**
  - National Board on Computer Science and Telecommunications
  - IETF, ATM Forum, Network Management Forum
  - Continued Participation in satellite industry work (TIA, Technical Committees, Alliance)

- **Continued influence on DoD telecommunications (ARL-ATIRP, DARPA workshops, Space Architect office, HLA office)**

- **Frequent brainstorming with industry partners, NASA and DoD on future long term network research problems**

Highlights of Major Accomplishments

- **Emphasized and increased efforts on manpower education (short courses, industrial internships, workshops)**
  - CSHCN has graduated in the period 1991-98: 29 PhDs, 62 MS, 24 BS (98% to US Industry)
  - Last three years 15 to 24 interns with US Industry, each summer
- **Closer and expanded collaboration with industry**
- **Continued technical emphasis on: hybrid networks, asymmetric Internet, interoperability, cost issues**
- **Focusing intensely on:**
  - High-data rate satellite networks, modeling, design and performance evaluation
  - Hybrid fast Internet over broadband hybrid networks (in particular future K_a-band systems)
  - Network interoperability
    - ➢ broadband satellite/terrestrial wireless (LMDS, MMDS)
    - ➢ mobile satellite/terrestrial wireless
    - ➢ broadband satellite/terrestrial wireline (HFC, fiber)

Hybrid Networks Laboratory
First Phase Completed
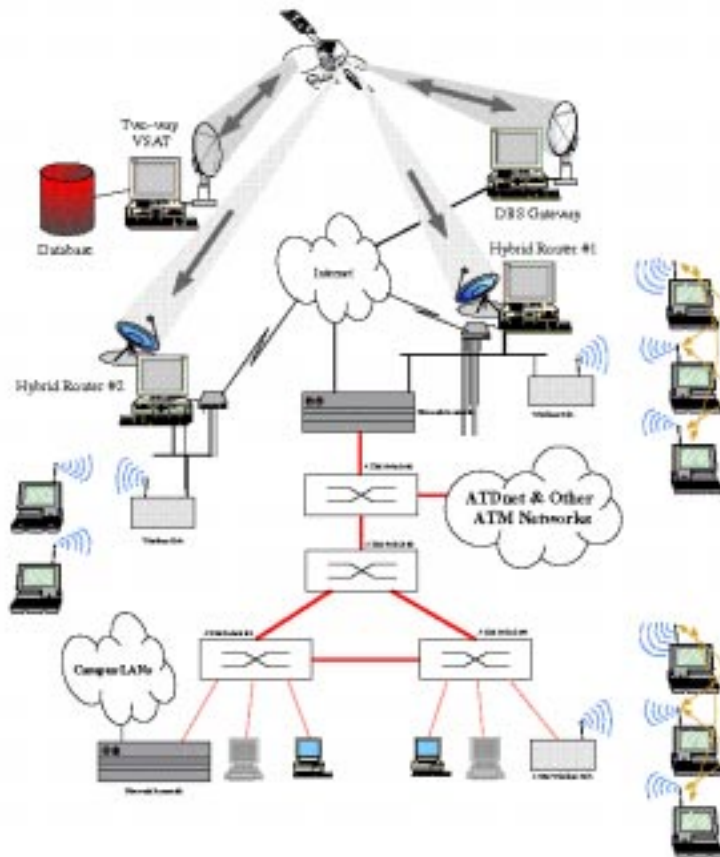
Plan for Hybrid Networks Laboratory

- Fully meshed ATM network with OC3/12 connections

- HP Broadband Test equipment with DS3, OC3, and OC12 modules

- ADTECH delay channel simulator with DS3, OC3 interfaces (will procure OC12 when available from manufacturer)

- Comsat Fast Packet switch

- Fully meshed mobile network using multiple wireless interfaces

- Hybrid Host Router capable of redistributing unicast, broadcast and multicast traffic streams

- Developed a system to study the effects of jitter on real time applications on ATM networks. This system can generate both bursty and constant bit-rate traffic

High-Data Rate Experiments and Demonstrations

- **Joint with NASA LeRC and industry**
  - Invite industry partners to declare interest in participating: make available satellite and/or terrestrial resources

- **Fast Internet over high-data-rate satellites**
  - SACK, RED, spoofing, caching, buffers, queue management, TCP improvements, new flow control
  - ATM, TCP/IP over ATM over high data rate satellites

- **Reliable, large scale multicasting**
  - Advantage of Hybrid Internet Access
  - High-data rate satellite adds reliability
  - Multicast delivery of bulky "information objects": movies, books, software, maps

- **Interoperability between high-data rate Ka-band satellites and LMDS systems**
  - What we gain by using the same frequency band? (K_a, 28 GHz)
  - Video delivery, and Fast Internet services

Outline

- CSHCN Structure and Partners

- Highlights of Major Accomplishments

- Technical Theme and Vision

- Collaboration with NASA and Support of NASA Missions

- Collaboration with Industry

- Education and Outreach

- Financial Summary

New Business Paradigm

Total Network Capacity Demand

The "New Data"

Traditional Voice/Video

Host-centric Data
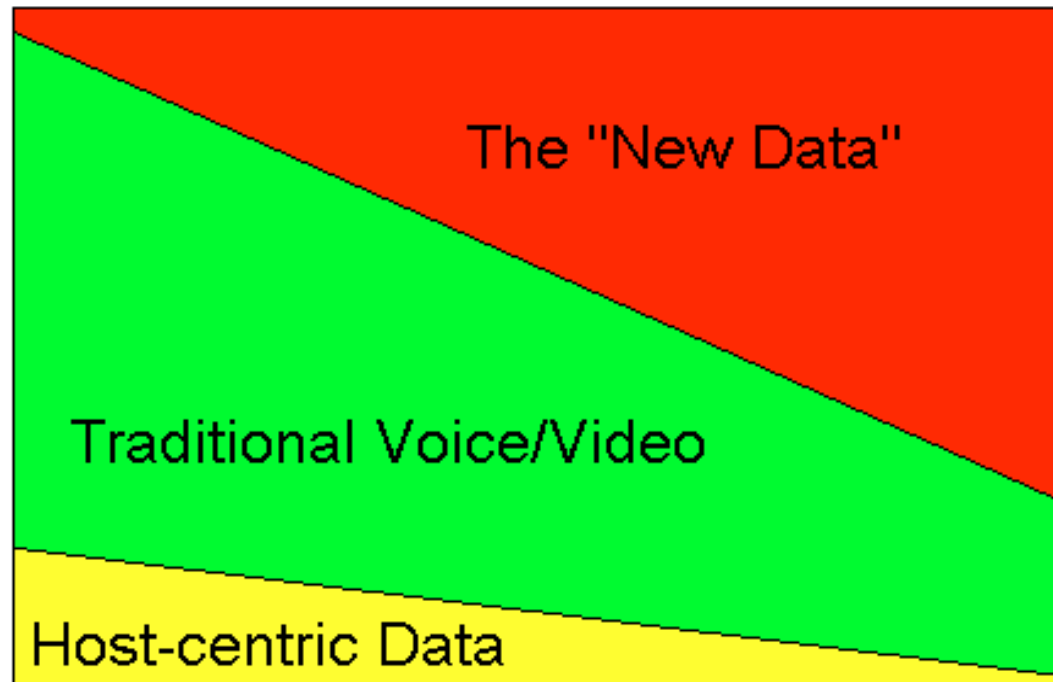
- **The "New Data": Internet / Intranet / Extranet applications**
  Digital, compressed voice, audio and video

- **Paradigm shifts:**
  - Data applications require flexible connectivity
  - Applications require much larger capacities and "bandwidth-on-demand"
  - Subscribers require low-cost, high capacity access
  - Enterprise networks require in addition scalability, dependable performance, simple network management, controlled costs

14

The "Last Mile" is Key

- ## Local Access options :
  - Fiber to anywhere (FTTN, FTTC, FTTH, SDV)
  - Copper twisted pair wire (ADSL, VDSL, … HDSL)
  - Cable Television (CATV), coaxial cable (HFC)
  - Multichannel Multipoint Distribution Service (MMDS)
  - Local Multipoint Distribution Service (LMDS)
  - Broadband Satellites

- ## Not a technology issue

- ## Economic and marketing issue

- ## Time of deployment & market penetration

Broadband Wireless Infrastructures

- **Many advantages of wireless infrastructures:**
  - Instant deployment
  - Flexible asset reuse and resource allocation
  - Ideal multi-service platform: voice, data, video
  - Access comparable to wireline access in price and performance
  - Lower initial investment & faster initiation of revenue
- **MMDS: 2.5 GHz with 200 MHz, 40 miles**
- **LMDS: 28 or 38 GHz with 1.5 Ghz, 3 miles**

Broadband Wireless Infrastructures: Satellite Constellations

- **DBS major success**

- **New remarkable satellite constellations**

  - FSS or Mobile, LEO or MEO

  - From 8kbps to 1 Gbps and higher; *on demand*

  - Competition to fiber ("faster than light")

  - On-board processing, spot beams, hoping beams, autonomy

  - Globalstar, Iridium, Teledesic, Spaceway, CyberStar, PanAmSat, Astrolink, ...

  - Newest EHF satellites: OrbLink, Lockheed Martin, ...

Vision: The "New Space-Time" plus "Smart Space"

Fact: The Internet will be the Information Superhighway:

it will carry video, voice, broadband data worldwide

Evolution (architecture) controlled:

Now: backbone   **Future:** "last-mile"

Problems: Data Smog; World-Wide Wait

Drivers for success: Economics and "customer psychology"

- Low, low price (terminals, nets, satellites, power)

- Availability and reliability

- Security

- Information "follows" the user

Architectures

Economics of Broadband

Economics of Last Mile

Imply: Intelligent
hierarchies
in architecture
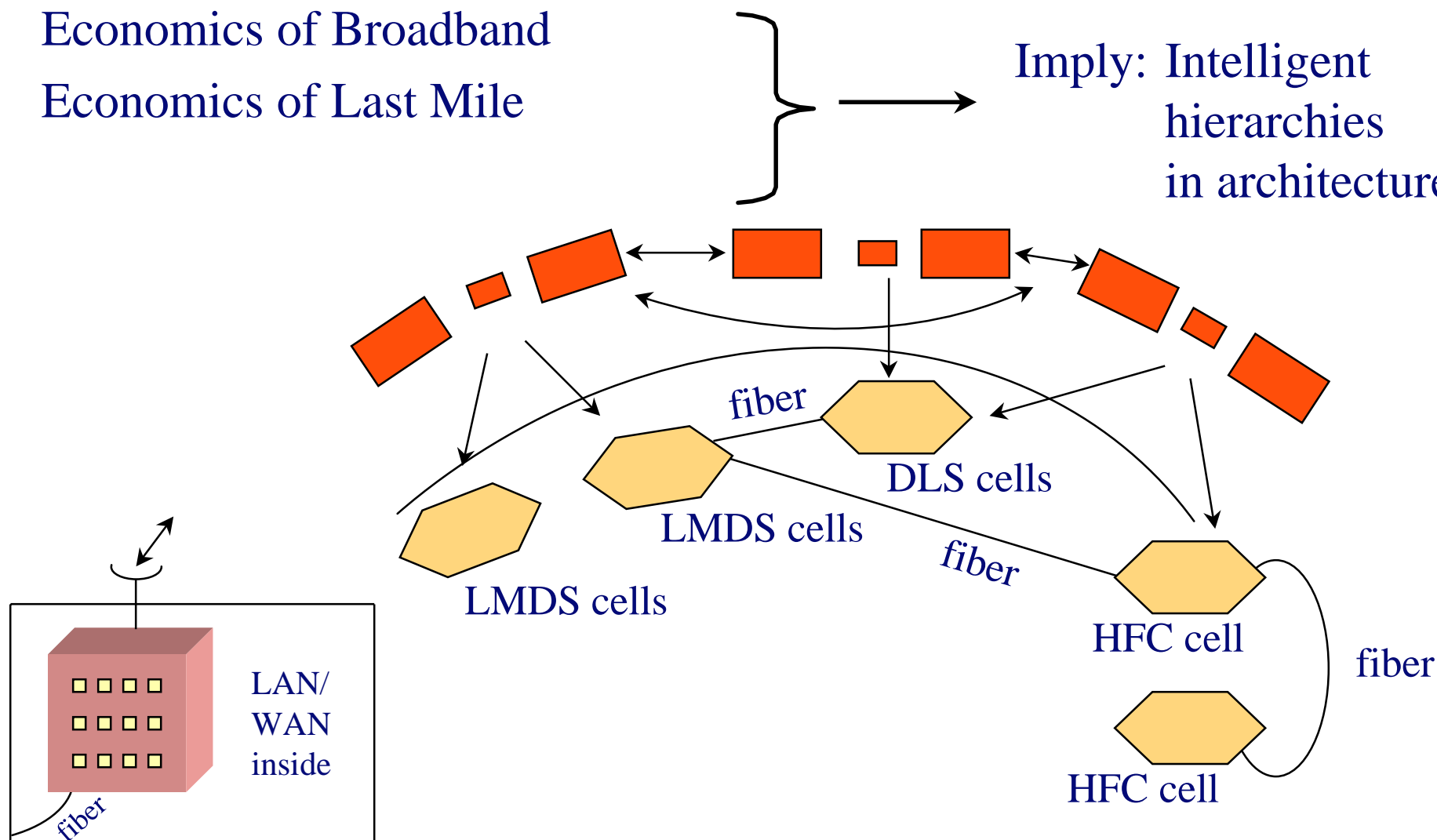
fiber

DLS cells

LMDS cells

LMDS cells

fiber

HFC cell

LAN/
WAN
inside

fiber

HFC cell

fiber

19

Two-way High-Data-Rate Satellite Connection

The rest of the Hybrid Network

ATM Fiber

Broadband Wireless Network

The Internet

Base Station

Base Station

- - - - - - 10 Mbps indoor Wireless LANs (500 m)
- - - - - - 1-3 Mbps outdoor Wireless WANs (2-3 miles)
- - - - - - 0.02-0.06 Mbps outdoor Wireless (Ubiquitous)
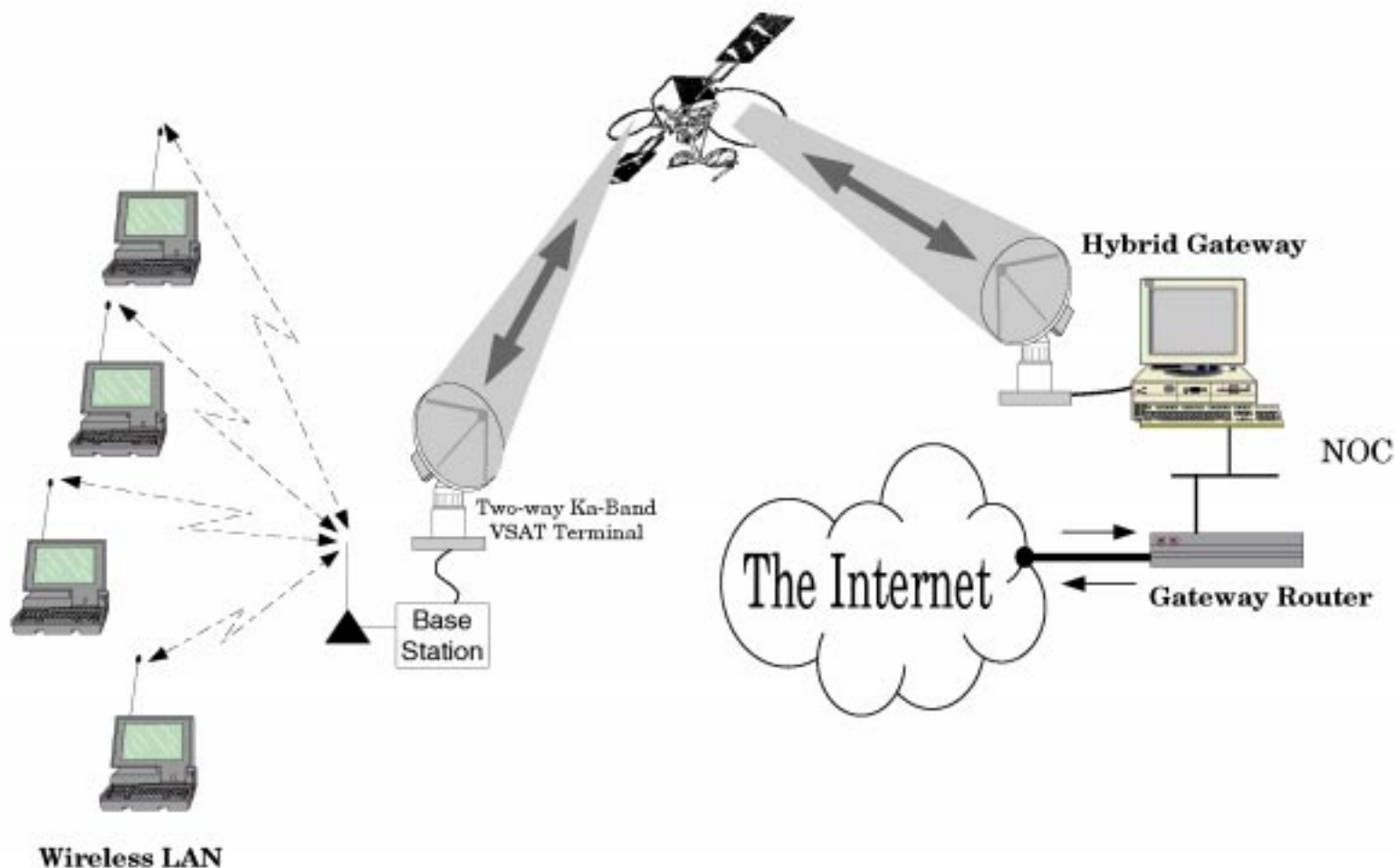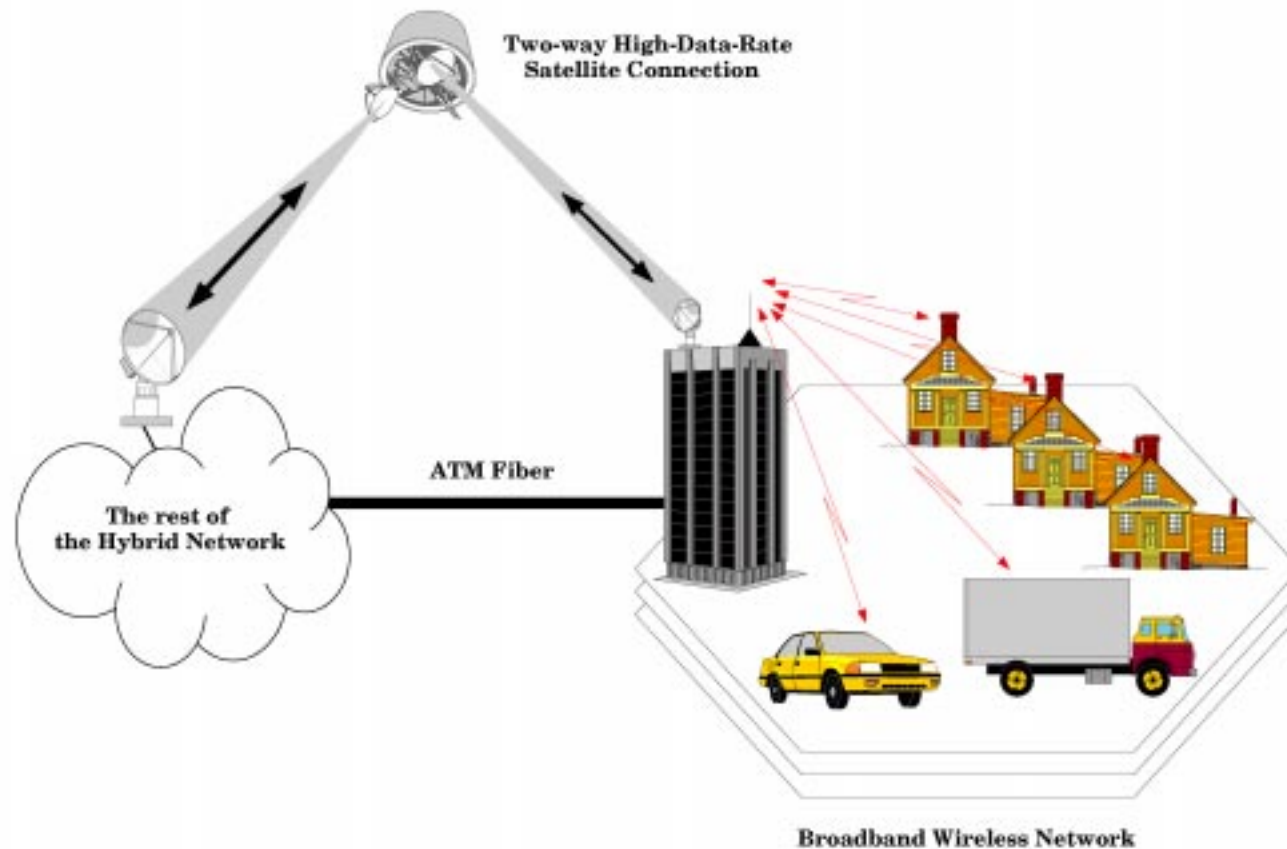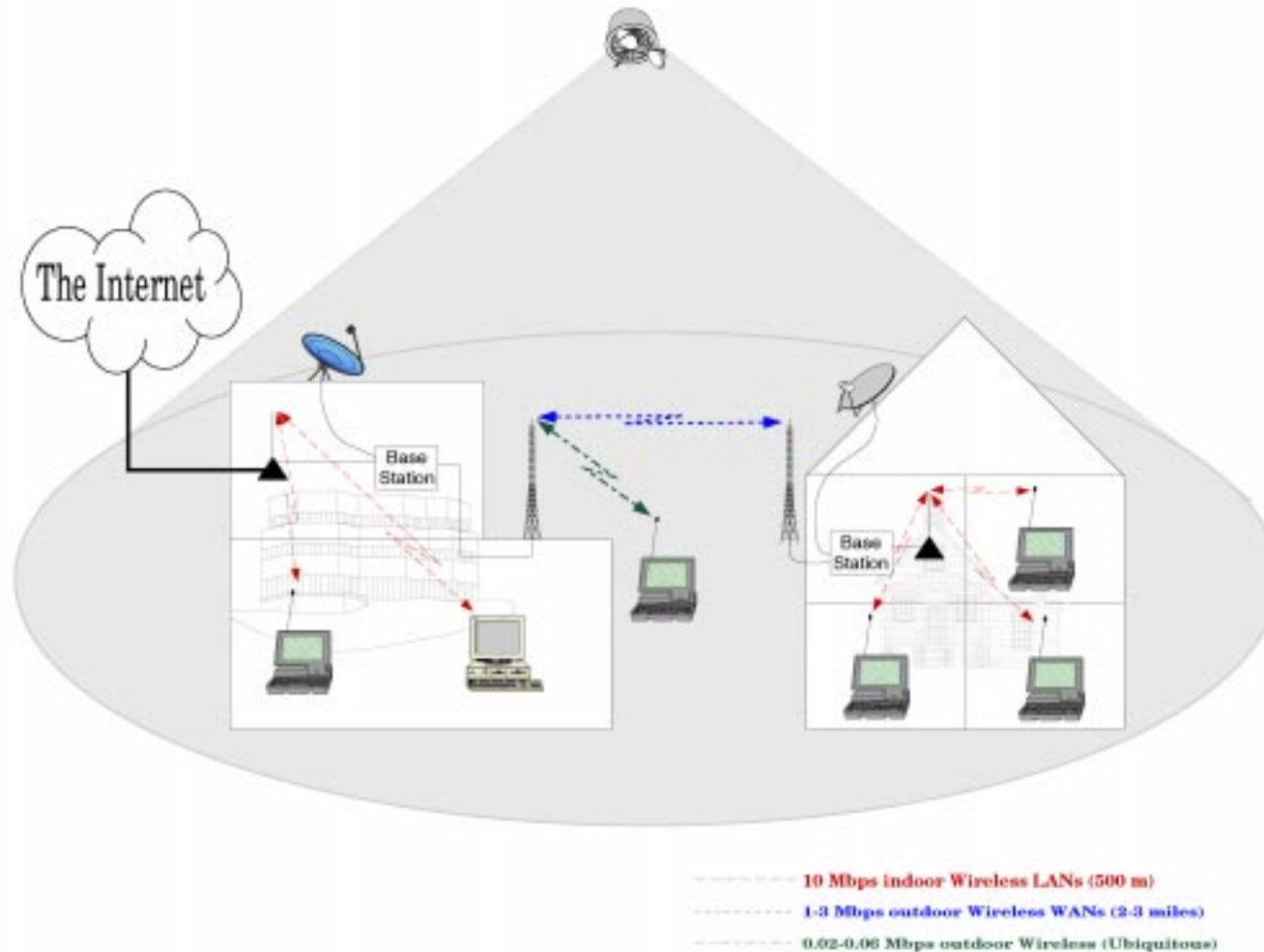
Efficient Broadband Services not just a Bandwidth Issue

- **Challenge: Exponential growth in demand workloads cannot be met by traditional data services with scalability growth linear in network bandwidth and server capacity**

- **Traditional unicast (point-to-point) connection-oriented data services uneconomical and wasteful**

- **Utilize distributed caching, smart prefetching, dynamic bandwidth allocation, reliable multicast, adaptive hybrid data delivery**

- **Need to broadcast the right set of data: highly in demand**
  - Balance data delivery modes to match user's request
  - Broadcast the right amount of the hottest data and provide the rest on demand

The "Last Mile"

- There will be no winner-take-all in the "last mile"

- LMDS will be widely deployed over the next 3-5 years

- MMDS will continue modest deployment in rural areas and outside the USA

- HFC broadband services will be deployed fast over the next 3-5 years, where CATV already exists

- Fiber to the CO and xDSL will deploy slowly over next 5-10 years

- Broadband satellites and wireless will be deployed extensively, especially outside the USA

Key Technical Challenges

- **Design of smaller satellites with on-board processing, autonomy**

- **Energy and cost efficient small end-user terminals**

- **Access equipment: PC cards and set-up boxes**

- **Local intelligence to "hide" heterogeneity: end-to-end simplicity**

- **Protocol re-design and integration, interoperability**

- **Hybrid network planning and design methodologies, tools**

- **Dynamic, adaptive routing, congestion and flow control**

- **Automated network management of hybrid networks:**
  - Databases, MIBS, Fault management, Configuration management, Performance management, Security management, Self-managed networks
  - Service pricing, cost and business models

- **Efficient information distribution and broadband services**

CSHCN STRATEGIC PLAN

TCP/IP and ATM over Satellite and Wireless

Modulation, Signaling, Access

Internet over Hybrid Networks including Hybrid Data Delivery

Switching and Routing

Multicasting including security

Network Management and Control

Interoperability

NOC design

Next Generation Hybrid Network Architectures including Mobility

Network Systems Engineering Tools including Performance Evaluation

Universal Interfaces and Subscriber Equipment

1999   2000   2001   2002   2003

26

Current CSHCN Projects

Internet over Broadband Hybrid Networks
Baras, Corson, Roussopoulos, Tassiulas

High Data Rate Satellite Networks and NASA Missions
Baras, Geraniotis, Hadjitheodosiou

Modulation, Coding and Interference Cancellation in Satellite and Hybrid Networks
Ephremides, Geraniotis, Hadjitheodosiou

Hybrid Network Control
Ephremides, Tassiulas

Satellite Traffic Modeling and On-Board Switch Design
Makowski, Narayan

Modeling, Simulation and Performance Evaluation of Hybrid Networks
Baras, Corson, Geraniotis

Automated Monitoring and Management of Hybrid Broadband Networks
Baras, Mykoniatis, Roussopoulos

Current and Future Technical Topics Emphasized

- Multicasting techniques for hybrid networks

- Internet-based high data rate communications from space to the users

- Next-Generation network architecture development tools

- Modulation and coding

- ATM-based on-board switching

- In-space wireless network/hybrid network interoperability

- Advanced hybrid networks research (modeling, simulation, performance evaluation, network management)

Outline

- CSHCN Structure and Partners

- Highlights of Major Accomplishments

- Technical Theme and Vision

- Collaboration with NASA and Support of NASA Missions

- Collaboration with Industry

- Education and Outreach

- Financial Summary

High Data Rate Communications from Spacecraft and Space-Missions

- **Commercial Space needs high data rate and high quality communications**
  - Experiments with Shuttle
  - Experiments with ISS
  - Spacecraft linkage
  - Future space habitats and planetary missions
- **NASA networks, spacecraft, instruments on the Internet**
- **Needed:**
  - Efficient and cost effective communications from spacecraft to commercial satellite constellations
  - Experiments to validate such systems

HDR Commercial Communication Services to the ISS

Future
High-Data-Rate
Ku/Ka band
GEO Satellite

Future
High-Data-Rate
Ku/Ka band
GEO Satellite

International
Space Station

1-2 Gbps Link

1-2 Gbps Link

48 Mbps

1. Commercial high-data-rate service to the Space Station.

2. CommNet redesign on the Space Station.

- Initiated interactive modeling and simulation of HDR telecomm services between the ISS and future HDR satellite constellations

- Special session in the ISS Utilization Conference, February 1999

Close Collaboration with NASA Centers

- **Close and intensive collaboration with NASA Lewis RC**
  - joint projects
  - student internships
  - faculty monthly visits (lecture, interactions)
  - joint experiments and demonstrations
- **Collaboration with NASA Goddard on ATM over HDB hybrid networks; interoperability**
  - take advantage of ATD Net and ACTS

Outline

- CSHCN Structure and Partners

- Highlights of Major Accomplishments

- Technical Theme and Vision

- Collaboration with NASA and Support of NASA Missions

- Collaboration with Industry
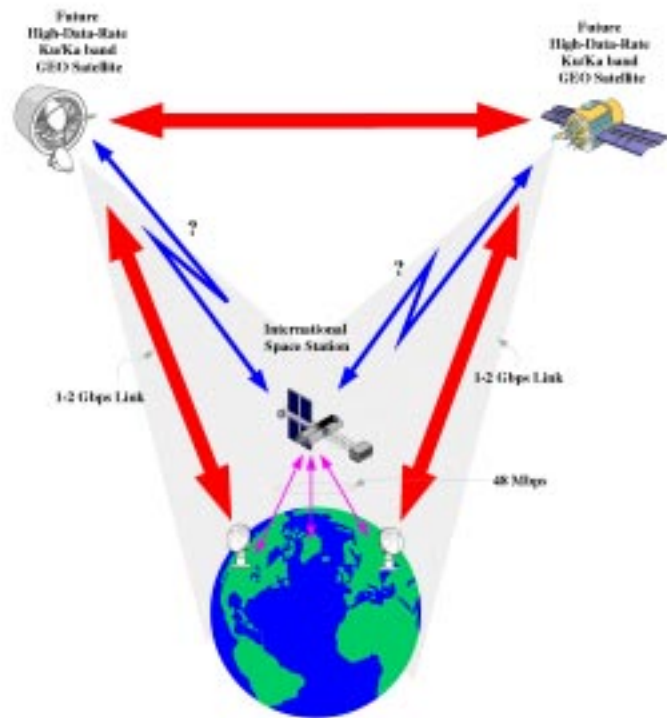
- Education and Outreach

- Financial Summary

CSHCN Partnership

- **Initiate and perform research and development in areas of strategic significance to industry. Facilitate effective commercialization.**

- **Be a catalyst in industry-university, industry-industry, industry-university-government collaboration**

- **Attract, educate and promote to industry and government expertly educated and trained professionals**
  - Undergraduate researchers and interns
  - Graduate researchers and interns

- **Develop and deliver timely, leading-edge education and training to industry/government**

- **Influence and guide national policy and national goal setting in technology R&D**

Outline

- CSHCN Structure and Partners

- Highlights of Major Accomplishments

- Technical Theme and Vision

- Collaboration with NASA and Support of NASA Mission

- Collaboration with Industry

- Education and Outreach

- Financial Summary

Education and Outreach

- Attract "best brains" in these technical areas

- Cross-disciplinary education to graduate and undergraduate students, coupled to industry and government internships

- Annual Review Conference

- Advanced Networks Colloquium (distinguished lecturers, videotapes)

- New educational initiates and paradigms

- Reach to user groups: telemedicine, distance learning

Outline

- CSHCN Structure and Partners

- Highlights of Major Accomplishments

- Technical Theme and Vision

- Collaboration with NASA and Support of NASA Mission

- Collaboration with Industry

- Education and Outreach

- Financial Summary

Graph of CSHCN Cash Contributions
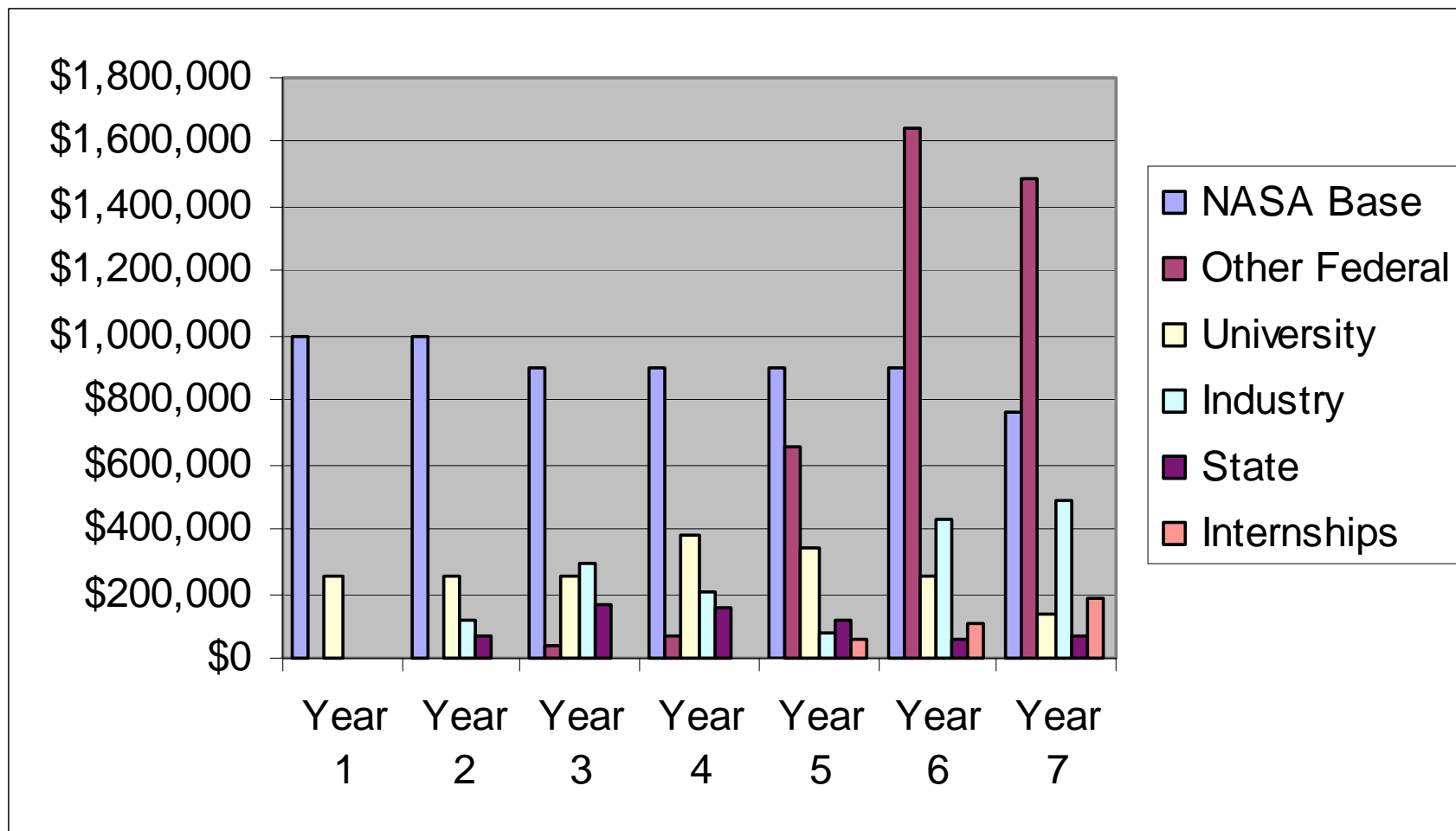
CSHCN Cash & Internship Contributions in Current Year

July 1, 1998 to present

NASA Base	$765,000
Other Federal	$893,994
University	$138,964
Industry	$411,344
State	$140,000
Internships	$185,911
TOTAL	$2,535,213

Center for Satellite and Hybrid Communication Networks

CSHCN

Education, Manpower and Outreach

John S. Baras

Industry Advisory Board Meeting
February 17, 1999

Education, Manpower and Outreach

From the CSHCN Partnership Strategy Chart:

- **Attract, educate and promote to industry and government expertly educated and trained professionals**
  - Undergraduate researchers and interns
  - Graduate researchers and interns

- **Develop and deliver timely, leading-edge education and training to industry/government**

Education, Manpower and Outreach

- **Critical shortage of well-educated and trained personnel in the technical areas represented in the CSHCN program**
- **Graduate and undergraduate students from Electrical Engineering, Computer Science and Business and Management**
- **Two special programs:**
  - MS in Systems Engineering
  - MS in Telecommunications
- **Create opportunities for "bright" undergraduates to participate in engineering design projects early on, often with industry collaboration**
  - Research Experience for Undergraduates (REU)
  - Undergraduate Research Participation Awards (URPA

Education, Manpower and Outreach: Strategic Initiatives

- Web-based interactive courses (ATM, Satellite Networks, Hybrid Internet)

- Initiated planning for new educational paradigm in telecommunication and information technologies (accelerated M.S. program modeled after Institute Eurecom)

- CSHCN monthly faculty visits and lectures at Government and Industry Partners

- CSHCN Advanced Networks Colloquium Series

- Rich web page on all aspects of CSHCN program; Private part for Partners

Center for Satellite and Hybrid Communication Networks

EXAMPLE: CSHCN Lectures at NASA LeRC

10/21/97   Novel Information Distribution Architectures and Methodologies Based on Broadcast Delivery *(Tassiulas)*

12/17/97   Rate-based Transmission Scheduling for Asymmetric, Satellite-based Reliable Multicast *(Corson)*

1/27/98   Hybrid Asymmetric Internet Services: Performance Enhancements, Extensions and Network Operations *(Baras)*

3/6/98   Statistical Tools For Fast Performance Evaluation and Optimization of High Data Rate Satellite Networks *(Geraniotis)*

3/10/98   Connection-Oriented Traffic Management over Hybrid Mobile Networks *(Ephremides)*

4/28/98   Performance Evaluation Tools for Hybrid LAN-ATM Interfaces for Multimedia Applications *(Narayan)*

11/5/98   OSI, TMN and CORBA for Network and Service Management *(Mykoniatis)*

- **Advanced Network Colloquium Series; Soon to be broadcast**

  - Graduate Student Participation
    - Four graduate students determine list of potential speaker

  - Speaker Visits
    - Lecture (every Friday, 11:00 a.m. - 12:00 p.m.)
    - Lunch
    - Roundtable Discussions

Center for Satellite and Hybrid Communication Networks

CSHCN

CSHCN ADVANCED NETWORK COLLOQUIUM SERIES
LIST OF SPEAKERS
1997 - 1998

SPEAKER	AFFILIATE	DATE	TITLE
Prakash Chitre	COMSAT Labs	11/21/97	New Development in ATM Over Satellite
C.J. Su	UMCP	02/13/98	Information Distribution Through Broadcast Delivery
Raj Jain	Ohio State University	02/27/98	Traffic Management of ATM Over Satellite Links
Balaji Prabhakar	MIT	03/06/98	Towards High-Speed, High Performance Data Switches
Tennis Ott	Bellcore	03/13/98	The Square-Root Formula for TCP Window Behavior and Stabilized RED
David McElroy	MIT	03/20/98	Key Technologies for Future Satellite communications Systems
Pierre Humblet	Eurocom Institute	04/03/98	Communication Over Fading Channels
Ioannis Paschalidis	Boston University	04/10/98	Providing Statistical QoS in Multimedia Networks (Effective Bandwidths and Beyond)
Richard Delanoy	MIT-Lincoln Lab	04/24/98	Toolkit for Image Mining: User-Trainable tools for Data Search, Image Analysis, and Algorithm construction
Samuel Dwyer	University of Virginia	05/01/98	Acquisition, Transmission, Display, Networks, and Archiving
David Forney	Motorola	05/08/98	On Iterative Decoding and the Forward-Backward Algorithm
John Baras	UMCP	09/11/98	The 'Last Mile', Hybrid Networks and Broadband Internet
Joseph Macker	NRL	09/25/98	The Multicast Dissemination Protocol
Rajiv Laroia	Lucent Technologies	10/02/98	Overview of High-Speed Access Over Existing Telephone Infrastructure
Walter Willinger	AT&T	10/09/98	The Fractal Nature of Data Traffic
Scott Corson	UMCP	10/16/98	Mobile Ad hoc Networking
David Tennenhouse	DARPA	10/23/98	From Internet to Active Net

CSHCN 1998 Summer Internships/Co-ops

Anjum, Farooq	Bellcore
Arora, Anubhav	Lockheed Martin Telecommunications
Barrett, Bradley	Howard University
Bharadwaj, Vijay	Lockheed Martin Telecommunications
Birmani, Vineet	Hughes Network Systems
ElGamal, Hesham	Hughes Network Systems
Gu, Junfeng	LNK Corporation
Han, Zhu	Hughes Network Systems
Kar, Koushik	Lucent Technologies
Karir, Manish	Hughes Research Labs
Khairy, Mohamed	Orbital Sciences
Koutsopoulos, Iordanis	Hughes Network Systems
Li, Hongjun	MCI
Luo, Wei	Hughes Network Systems
Parulekar, Minothi	Hughes Network Systems
Payne, Stephen	Army Research Laboratory
Ramakrishnan, Arvindha	Bellcore
Ramakrishnan, Pradeep	Yurie Systems (Lucent)
Ramaswamy, Sreenivas	Comsat Labs
Sarkar, Saswati	IBM
Stamatelos, Dimitrios	Schafer Corporation
Tabatabaee, Vahid	Yurie Systems (Lucent)
Tripathi, Rohit	Lockheed Martin Telecommunications
Vaidyanathan, Ravichander	Bellcore

CSHCN Employers

ADVANTIS	Iterated Systems, Inc.
AIMS, Inc.	JP Morgan
Arthur Anderson	Lucent Technologies
AT&T Bell Laboratories	Microsoft
BDM	MIT Lincoln Labs
Bell South	MITRE
Bellcore, Inc.	MITRE Technical systems
Berkeley.Nets	Motorola
Booz Allen	National Institute of Health
CENA	Northern Telecom
Cisco	Performance Eng. Corp.
Computer Science Corporation	Qualcomm
COMSAT Labs	Raytheon
Comsearch, Inc.	Stanford Telecommunications
FORE Systems	Telogy Networks, Inc.
GEISCO	Texas Instruments
GTE Lab	Texas Instruments Research Labs
Hi-Tech Resources, Inc.	TRW
Hughes Network Systems	U.S. Sprint, Inc.
Hyundai Electronics America	United Airlines
IBM Watson Labs	Visix Corp.
InterWave, Inc.	VLSI Technologies, Inc.
Intracom S.A.	Yurie Systems

CSHCN Student Alumni List
1991-1998
(Through Fall 1998 Semester)

Ph.D. STUDENTS

NAME	ADVISOR	DEPT	YEAR	FIRST/CURRENT AFFILIATION
Ayyagari, Deepak	Ephremides	EE	1998	GTE Labs – Cambridge, MA
Banege, Lionel	Makowski	EE	1996	CENA
Chang, Yu-Wen	Geraniotis	EE	1996	InterWave, Inc.
Chen, Shihwei	Baras	EE	1994	Yurie Systems
Chou, Chih-Hsien		EE		Unknown
Corson, Scott	Ephremides	EE	1993	University of Illinois, Chicago
Datta, Anindya	Ball	BGMT	1994	University of Arizona
Delis, Alex	Roussopoulos	CS	1993	Unknown
Frantzeskakis, Emmanuil	Baras	EE	1993	Intracom S.A. (Greece)
Issac, David	Roussopoulos	SE	1994	MITRE
Kanlis, Angelos	Narayan	EE	1997	The University of Crete, Greece
Kao, Yu-Hung	Baras	EE	1992	Texas Instruments Research Labs
Khudanpur, Sanjeev	Narayan	EE	1997	The Johns Hopkins University
Kim, Young B.	Makowski	EE	1996	Telogy & Hyundai Electronics America
Kuang, Lei	Makowski	EE	1992	ADVANTIS (Currently at IBM Networks)
Lambadaris, Ioannis	Narayan	EE	1992	Unknown
Li, Jerry	Geraniotis	EE	1997	GTE Lab, Waltham, MA
Lin, Feng Lee	Ball	BGMT	1992	National Sun Yatsen University
Lin, Ie-Hong	Geraniotis	EE	1994	Comsearch, Inc.
Liu, Shang-Chien	Geraniotis	EE	1998	Lucent Technologies
Modiano, Eytan	Ephremides	EE	1992	MIT Lincoln Labs
Peris, Vinod	Makowski	EE	1997	IBM Watson Labs
Rananand, Nol	Narayan	EE	1995	FORE Systems (Currently at COMSAT)
Rezaiifar, Ramin	Makowski	EE	1996	Qualcomm
Stathatos, Konstantinos	Baras	CS	1998	Bellcore (Applied Research Department) Morristown, NJ
Tassiulas, Leandros	Ephremides	EE	1992	Polytech Institute of NY
Vakhutinsky, Andrew	Ball	BGMT	1996	United Airlines
Wu, Tsing-Hsien	Geraniotis	EE	1994	Bell South
Yang, Wen-Bin	Geraniotis	EE	1993	Comsearch, Inc.
Yao, Shee	Geraniotis	EE	1997	VLSI Technologies, Inc.
Zhuang, Yan	Baras	EE	1994	Iterated Systems, Inc. - 1995

M.S. STUDENTS

NAME	ADVISOR	DEPT.	YEAR	FIRST/CURRENT AFFILIATION
Agarwal, Manoj	Ephremides	EE	1993	Texas Instruments
Almeida, Fernando	Baras	EE	1995	Computer Science Corporation
Anjum, Farooq M.	Tassiulas	EE	1997	Graduate – Working towards PhD
Arora, Anubhav	Baras	EE	1998	Graduate – Working towards PhD
Arora, Vivek	Baras	CS	1995	AT&T Bell Laboratories
Ayyagari, Deepak	Ephremides	EE	1996	Graduate - Working towards PhD
Bisain, Abhijeet	Baras	EE	1998	Qualcom
Chan, Wai-Chung	Geraniotis	EE	1995	Graduate - Working towards PhD
Charleston, Giles	Makowski	SE	1997	MITRETEK
Chen, Bin	Baras	EE	1998	Hughes Network Systems
Chen, Chao-Hwa	Fuja	EE	1995	Graduate - Working towards PhD
Das, Arnab	Narayan	EE	1996	Graduate - Working towards PhD
Delancy, Sandra	Baras	SE	1993	BDM
Dogu, Talat Mert	Ephremides	EE	1998	Hughes Network Systems
Dorsey, Molly Bryson	Baras	SE	1993	AT&T
Ercetin, Ozgur	Tassiulas	EE	1998	Graduate – Working towards PhD
Falk, Aaron	Baras	SE	1994	TRW
Friedman, Daniel	Ephremides	EE	1995	Graduate - Working towards PhD
Fruth, Frank	Geraniotis	EE	1998	Telogy Networks, Inc.
Goli, Shravan	Roussopoulos	CS	1994	Microsoft
Gupta, Sandeep	Baras Roussopoulos	CS	1996	Berkeley.Nets
Gupta, Sonjai	Ephremides	EE	1996	Hughes Network Systems
Jiang, Yimin	Baras	EE	1998	Hughes Network Systems
Jog, Ninad	Shneiderman	EE	1995	Visix Corp.
Johnson, Brian	Farvardin	EE	1995	GRA @ UMC (Currently @ HNS)
Kamal, Ahmad	Geraniotis	EE	1993	Hughes Network Systems
Kant, Nishi	JaJa	EE	1994	Northern Telecom
Kawle, Mandar	Ball	RE	1994	Unknown
Khan, Khursheedul	Ephremides	EE	1996	Comsearch
Khairy, Mohamed	Geraniotis	EE	1997	Graduate – Working towards PhD
Kumar, Harsha P.	Shneiderman	SE	1994	Bellcore, Inc.
Liu, Mingyan	Baras	SE	1997	Research Staff UMCP-Wrkng towards PhD
Luo, Wei	Ephremides	EE	1997	Graduate – Working towards PhD

CSHCN Student Alumni List
1991-1998
(Through Fall 1998 Semester)

M.S. STURDENTS (Continued)

NAME	ADVISOR	DEPT.	YEAR	FIRST/CURRENT AFFILIATION
Michail, Anastassios	Ephremides	EE	1997	Graduate – Working towards PhD
Misra, Archan	Baras	EE	1996	Bellcore & PT PhD program at UMCP
Murad, Ahsun	Fuja	EE	1992	COMSAT Labs/PhD program @ UMCP
Olariu, Gabriel	Baras	SE	1997	Hughes Network Systems
Pang, Xiaozhong	Baras	EE	1998	Hughes Network Systems
Paranjape, Deepak	Ephremides	EE	1992	Unknown
Qui, Chencheng	Shneiderman	CS	1995	Graduate – Working towards PhD
Ramaswamy, Venkateshwaran	Baras	EE	1998	Qualcomm
Rao, Sandeep	Narayan	EE	1997	Hughes Network Systems
Secka, Isatou	Baras	SE	1997	Hughes Network Systems
Shah, Parthiv	Baras	SE	1996	Motorola
Singh, Gagan	Baras	EE	1997	JP Morgan
Sivarajan, Rajesh	Narayan	EE	1994	TRW (Currently @ HNS)
Srinivasarao, Mulugu	Ball	BGMT	1994	U.S. Sprint, Inc.
Stagarescu, Marian	Baras	EE	1998	Raython
Stamatelos, Dimitrios	Ephremides	EE	1995	Graduate – Working towards PhD
Stathatos, Konstantinos	Baras	CS	1994	Graduate – Working towards PhD
Taj, Azhar Paul	Ball	SE	1994	Hi-Tech Resources, Inc.
Tatake, Sachin	Baras	EE	1998	Stanford Telecommunications
Tan, Michael	Roussopoulos	CS	1993	Graduate – Working towards PhD
Tran Luu, Tung-Phong	Ephremides	EE	1995	Unknown
Tsoukatos, Konstantinos	Makowski	EE	1994	Graduate – Working towards PhD
Tunpan, Apinun	Corson	CS	1997	Graduate – Working towards PhD
Turo, David	Shneiderman	CS	1993	GEISCO
Valluri, Jaibharat	Baras	EE	1996	Hughes Network Systems
Viswanathan, Prem	Baras	EE	1996	U.S. Sprint, Inc.
Wu, Shiyi	Baras	EE	1996	Telogy Networks, MD

B.S. STUDENTS

NAME	ADVISOR	DEPT.	YEAR	FIRST/CURRENT AFFILIATION
Abu, Muritala	Baras	EE	1997	MITRE Technical Systems
Aylay, Adam	Baras	EE	1997	Hughes Network Systems
Bakshi, Karun	Baras/Corson	EE	1996	Comsat/Working towards MS Degree
Charuhas, George	Baras	BGMT	1994	Booz Allen
Goldman, Judy	Baras	EE	1995	Research Asst-University of Illinois
Gupta, Rajarshi	Narayan	EE	1997	GRA, University of CA, Berkeley
Holleman, Keith	Baras	CS	1998	Cisco
Hsu, Kevin	Baras	CS	1996	Unknown
Jang, Kap Do	Baras	EE	1992	Performance Eng. Corp.
Jen, Ting-Juin	Baras	EE	1998	Unknown
Karir, Manish	Baras	EE	1996	Graduate - Working towards MS
Kurichh, Rishi	Baras	EE	1997	NIH – Working towards MS, part time
Nguenkam, Pascal	Baras	EE	1997	Unknown
Pal, Fouzan	Narayan	EE	1993	Arthur Anderson
Peters, Steven	Baras	EE	1996	AIMS, Inc.
Pluempitiwiriyawej, Charnchai	Baras	EE	1995	Unknown
Rempas, Rommy	Baras	EE	1996	Unknown
Sabnis, Arun	Baras	EE	1996	Hughes Network Systems
Suphasindhu, Narin	Baras	SE\EE	1996	Fore Systems
Suri, Shikha	Baras	EE	1996	Unknown
Tso, Stanley	Baras	CS	1995	Unknown

Center for Satellite and Hybrid Communication Networks

CSHCN

Industrial Affiliates Program for the CSHCN

John S. Baras

Industry Advisory Board Meeting
February 17, 1999

Industry, University, Government Partnership

- **CSHCN Partnership: MISSION**

  Lead the research and development, demonstration, education and commercialization of hybrid network technologies and promote an efficient and economic global information infrastructure

- **Agreement and structure finalized with the University of Maryland**

CSHCN Partnership: STRATEGY

- Initiate and perform research and development in areas of strategic significance to industry. Facilitate effective commercialization.

- Initiate and perform research and development of critical importance to Government (NASA, DOD, NSA)

- Be a catalyst in industry-university, industry-industry, industry-university-government collaboration

- Attract, educate and promote to industry and government expertly educated and trained professionals

- Develop and deliver timely, leading-edge education and training to industry/government

- Influence and guide national policy and national goal setting in technology R&D

- **Partnership Agreement will entitle Partners to a set of valuable broad and specific benefits.**

- **$25K per year Partner contribution. Three years**
  - Partners are expected to have major involvement with CSHCN through additional directed and proprietary funded projects, student internships and joint contract work for the government
  - Consulting remuneration to faculty and research staff not included (private agreement between Partner and consultant).

- **Position on CSHCN Industry Advisory Board: Influence direction and execution of CSHCN programs**

- **Affiliates of CSHCN (as a group) are provided first opportunity to negotiate exclusive license of R&D results from CSHCN programs, (those resulting from general funds, not those resulting from directed or proprietary funding)**

- **Dedicated program review days at CSHCN (2 days per partner per year)**
  - total program or a portion of it

- **Dedicated and targeted recruitment of CSHCN students for Partner**
  - Screening of students
  - Holding dedicated to Partner recruitment events
  - Provide special opportunities for Partner to enhance Partner visibility and appreciation among student body

- **One "stop" referral of CSHCN faculty, research staff and students for consulting services (one "phone call away", or one "e-mail away" help)**
  - Maintain current profiles of researchers
  - Match people to requests; follow-up to facilitate engagement

- **Development and delivery of topical short courses requested by Partners**
  - On Partner site
  - Electronically or via video conference
  - Here at the CSHCN for small groups of Partner personnel
  - 1 week; 1 day a week
- **On-demand intensive custom workshops (two per year, 2-3 days each)**
  - Single Partner
  - Multiple Partner
- **Faculty and research staff visits (short: 1-2 days) to Partner site**
  - give detailed seminar on current work
  - participate on-site in topical discussions with Partner personnel
  - help in recruiting students

- **Free participation to CSHCN Software Library and Club**
  - Offer for R&D purposes CSHCN software
  - Priority in licensing of CSHCN software

- **Priority response to requests for research work and consulting support**

- **Extensive and advanced information dissemination of CSHCN R&D results via a web page for Partners only**

- **Cooperative programs, including the placement of visiting industry scientists or engineers at the CSHCN**

- **Option for free membership in ISR Industrial Affiliates Program**